FUNDAMENTALS
of
BUILDING INSULATION

Prepared by the

INSULATION BOARD INSTITUTE

in cooperation with the

NATIONAL MINERAL WOOL ASSOCIATION
and the WOOD FIBER BLANKET INSTITUTE

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FOREWORD

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This material has been written primarily for use by the National Retail Lumber Dealers Association, sponsors of the Thirty-day Short Courses for Veterans in or about to enter the lumber business.

It is not intended as a comprehensive text on the subject of building insulation but rather to give to the man selling building materials an understanding of how insulation works, why it is used and where to use it.

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SUGGESTED REFERENCES IN BUILDING INSULATION

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SECTION I

HISTORY OF INSULATION

INTRODUCTION

While manufactured insulation may be considered a comparative newcomer in the building field, insulation has been a part of our lives ever since the caveman first threw a bearskin over his shoulders for warmth. The first attempts of shelter, while primarily to protect man from the elements, assumed certain forms of insulation which are still used today.

We have only to pick up an early history book to read of the thick adobe walls of houses built in hot climates, the thatched huts of the colder zones or the ice igloos of the far North. All of these types of buildings had primarily the same purpose - to furnish shelter to the occupant and to keep the building as warm or as cool as possible.

A more personal example of insulation is the clothing we wear during the day or the blankets we cover ourselves with at night. The reason for the clothing or blankets is to maintain the body at a comfortable temperature. In other words, these materials act as "insulators" to keep the heat of the body from passing from it too quickly. We use insulation in the walls and ceilings of a building for the same reason - that is, to keep heat where it belongs - inside in winter....outside in the summer.

In addition to fuel conservation, insulation has a marked effect on comfort. The surface temperature of a wall or ceiling too hot in the summer or too cold in the winter no matter how much fuel is burned, will affect bodily comfort. When the wall is colder than the skin temperature, heat is rapidly drawn from the body and no matter how much fuel is burned and no matter what air temperature is shown by the thermometer, the body will nevertheless lose heat to the wall and discomfort will result. The opposite is true in the summertime. If the surface temperature of the wall or ceiling is higher than the skin temperature of the body, heat will be radiated to the body and summer discomfort will result.

Through the centuries we have progressed in house design until today the two foot to four foot adobe wall or thatched hut has become much less in thickness and coupled with the use of modern insulating materials, this much thinner wall has six to ten times more resistance to the passage of heat than the uninsulated house of yesterday.

PAST

We have on record many cases where insulation has been used prior to the commercial types of insulation we have on the market today.

It can be easily appreciated that the crude forms of materials used in the early days are not practical for the homes of today. However it is interesting to note the development of insulating materials from the early times into the forms that we use in today's homes.

One of the earliest uses of insulation was by James Watt who used wood strips for insulation in his steam experiments. These proved inefficient and the first known use of mineral wool came about in 1840 when an inventor in Wales developed that product and it became standard practice to insulate the steam boilers with mineral wool. It was first introduced into the United States about 1882.

The Armstrong Cork Company acquired rights for the manufacture of corkboard in 1900 and a plant for such manufacturing was built in Beaver Falls, Pennsylvania.

Insulating boards were manufactured in 1914 in Minnesota by the Insulite Company. In 1920 the Celotex Corporation made an insulating board from bagasse or sugar cane fiber.

The Aluminum Company of America have been largely responsible for the marketing of reflective type materials, although the first patents were issued in 1804.

From such beginnings there have developed insulating materials which have provided a major contribution to the comfort and economical operation of the home. It is doubtful if any other building material product introduced in the last decade has done more to make the building or home a better and more desirable shelter.

PRESENT

Because of their greater efficiency, manufactured products have taken the place of early-day primitive insulations. We still hear occasionally of where straw, sawdust or other vegetable fibers have been used as an insulating medium but such materials have proved of little value in their natural state as they are not resistant to moisture or fire, and will dry rot or decay over a short period of time.

The insulating materials of today are handled largely by the lumber and building supply dealer. They are produced to uniform quality and weights -- thicknesses and sizes are all controlled. In addition, the materials, where necessary, can be treated to make them resistant to moisture, vermin and fire. Insulation is probably the only material added to a homebuilder's bill of goods that will pay back dividends to him.

Present insulations cover a wide variety of shapes, sizes and materials. We have on the market today bulk type materials that can be used as a fill or blown into ceilings or walls during or after construction; the batt and blanket types for use in walls and ceilings, reflective types for use in framing members and rigid fiber board for use as sheathing, plaster base and interior finish.

There are on the market today materials which will solve every conceivable insulation problem. All phases of the utilization and application of insulating materials have been exhaustively studied by the individual manufacturer. The general public can accept these findings and use insulating materials with confidence in that they can be installed under all kinds of climatic conditions and in every type of building construction.

FUTURE

During World War II the use of building insulation was recommended by the Government in their national fuel saving program. Millions of square feet were used by the Government in buildings both at home and abroad. Insulation received considerable recognition as a material for use in all types of construction where heating plants were used.

With fuel rationing in effect during the war the home owner learned that insulation could give him a comfortable home with less fuel during cold months. He also became aware that his home was cooler in warm weather when insulation had been used.

The recent survey of the Curtis Publishing Company indicated that 87.3% of the people intending to build homes of the pre-war $6,000 class intended to insulate and would spend $226 extra for that insulation. The use of year-round air conditioning in residential buildings will require insulation in some form. Research is continuing in all fields of home insulation. It may well be said that an uninsulated house will soon be an unsaleable house, and the information on insulation is becoming so widespread that prospective homeowners or even renters are inquiring as to the efficiency of the insulation and whether it is used in both ceilings and walls as well as under the floors in basementless houses. This applies to the entire country as the advantages of insulation for fuel saving and winter comfort are rapidly being recognized in the cold climates, and the advantages of summer comfort as well as reduction of air conditioning costs are being rapidly recognized in the warmer climates.

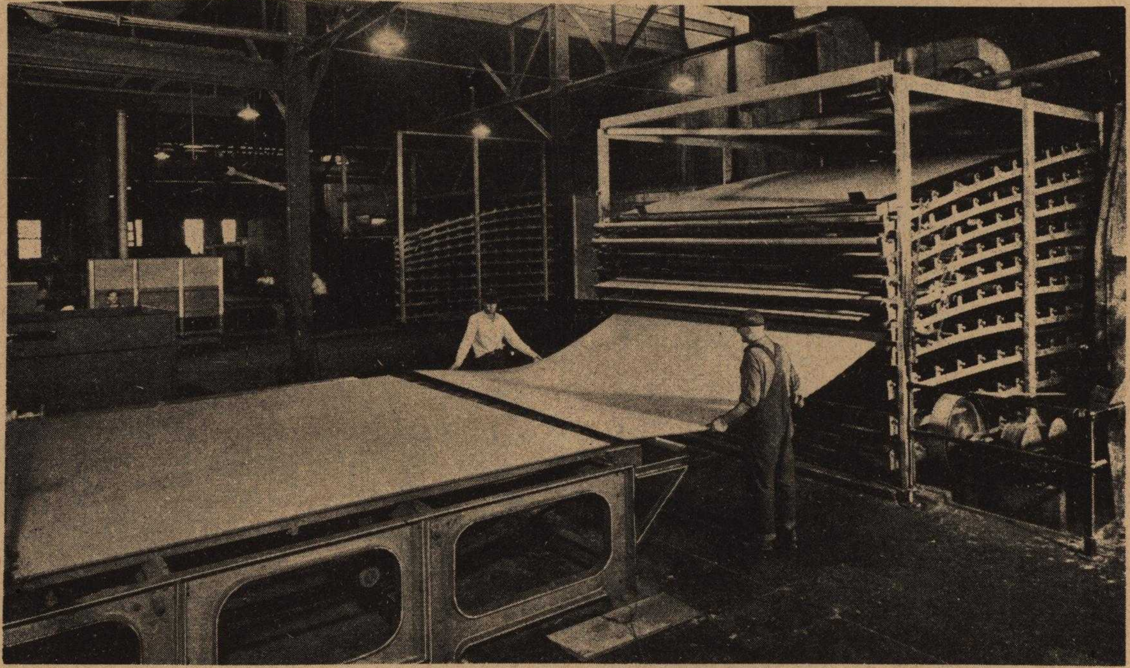
Because manufactured insulation is comparatively new, and because it is a profitable "plus" item for dealers, it is important for you to know the principles by which insulation accomplishes its results as well as the forms in which it is manufactured.

It is also apparent that insulation will find an increasingly greater demand in the future, with the advent of radiant and panel type heating plants and the increasing use of solar radiation for heating the small home.

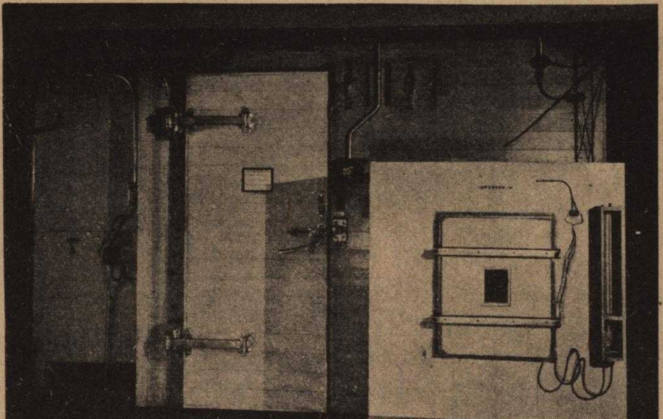
As mechanical cooling units as well as all types of heating equipment become more automatically controlled insulation will assume greater importance to the home. Each new mechanical device introduced in the house is attempting to reduce the work and provide more leisure for the home owner. Insulation will of necessity be a requirement in such homes.

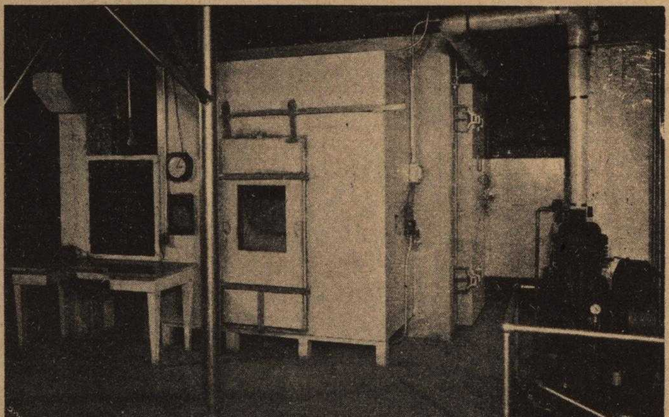
The products of tomorrow may vary in shape, weight and size, but basically the principle will remain unchanged. It may well be said that in the future the home owner will be as interested in knowing if the home is insulated as in knowing if the house has a bathroom.

MODERN INSULATING BOARD FACTORY
SHOWING SHEET OF INSULATING BOARD LEAVING DRIERS



TEST ROOMS AT THE UNIVERSITY OF MINNESOTA
USED IN RESEARCH WORK FOR INSULATION MATERIALS.





SECTION II

WHY AND HOW OF INSULATION

HOW HEAT IS LOST FROM A BUILDING AND HOW IT MAY BE GAINED

All building materials such as wood, masonry, etc., and even wide air spaces permit the passage of heat from the interior to the exterior in winter or from the exterior to the interior in summer. This applies even to insulation. Insulation does not completely stop the passage of heat but it is manufactured for the express purpose of retarding the greatest possible amount of heat in area insulated. Just how does insulation work? First of all, to understand it let us examine the personal heating system. Your body has its own furnace and unless you are ill, stays at one temperature, normally 98.6° summer and winter. The amount of heat you generate is, in fact, more than you can stand, and you are constantly throwing off heat. If you did not, you would suffer from fever, but when this heat escapes too fast you feel cold and have goose flesh as your body works hard to make up for its loss.

Heat is lost from a building in one of the following ways or by a combination of them: (1) conduction, (2) convection and (3) radiation.

CONDUCTION. If you sit on a cold stone step or a metal chair you feel instantly the discomfort that comes from the contact of your warm body with the colder surface; this way of losing heat by contact is called CONDUCTION.

CONVECTION. Drafts across the ankles or down your neck are unpleasant because they remove heat unevenly; the moving air carries away heat by CONVECTION.

RADIATION. The heat you lose by the third method is less obvious, but in its understanding lies the secret of assuring comfort in your home. Radiated heat moves at high speed through the air without heating the air and flows in direct lines from a warm surface to a cooler one. Sun heat is radiated heat; heat going from your body to a nearby colder surface, like a wall or ceiling, is also radiated heat.

You can warm the furnishings, the objects you touch in your home, by heating the air, as your furnace does. You can close windows to avoid drafts. But even if your room is heated to a livable 70°, you cannot be comfortable when cold walls, ceiling and floors are drawing too much heat from your body by radiation. In a sense, then, your body-heat is heating your own walls. Heated air warms too but without insulation it cannot keep up with the loss to the outside. Here then is insulation's simple job - to make walls, ceilings and floors resistant to the escape of heat from indoors. Heat stays within such walls to create a surface temperature near that of the indoor air. In summer, outdoor heat is held within the wall and results in a lower interior surface temperature than would be the case without insulation.

The transfer of heat through building materials takes place almost entirely by conduction although in rare cases convection may be a minor factor. On the other hand, the transfer of heat through air spaces takes place by all three types of heat transfer. But heat transfer by any method is reduced by including insulation in walls or ceiling.

HOW HEAT IS TRANSFERRED THROUGH A BUILDING MATERIAL

The passage of heat through building materials is chiefly by conduction, the heat always going from a warmer area to the colder side. There are several factors that determine this passage of heat. They are:

(1) Temperature difference between the two surfaces - the greater the difference in temperature the more heat per unit of time that will be transferred. If you have an inside temperature of 70° and an outside temperature of 0°, more heat units per hour per square foot will go through the wall than if the outside temperature were 30°.

(2) Thickness - less heat is transferred through thicker materials (Conductivities being equal).

(3) Area - the larger the wall or ceiling area, the greater the amount of heat transferred.

(4) Time - the amount of heat transferred is proportional to the number of hours during which the heat flow takes place.

(5) Rate - rate of heat transfer will affect the amount of heat going through a wall. This will depend on the physical characteristics of the material and how fast a material conducts the passage of heat, and the temperature difference between the high or low point.

HOW INSULATION RETARDS THE FLOW OF HEAT

We have pointed out how heat is transferred through a building material and how heat is lost from a building. We shall now discuss how insulation retards the flow of heat. When the channel of a stream is obstructed, the water flows sluggishly or is forced into other outlets. Insulation acts to retard heat flow in the same way when placed in wall, ceiling or floor. In other words, less heat will pass through an insulated wall and ceiling in a given period of time if insulation is included and the more heat resistance of the insulation, the less heat will go through the construction.

Practically all insulations are made of porous, light-weight materials. These manufactured materials are formed with millions of air pockets or voids in them. The air pockets are due to the separation of the vegetable or mineral fibers that make up the insulation at time of manufacture. Each of these tiny air cells has its own "sphere of influence," that is, each tends to retard the heat flow, and this type of insulation is efficient in controlling heat flow because it has so low a rate of heat transfer by conduction. These mass insulations allow no transfer of heat through them by convection or radiation.

Reflective materials retard the flow of heat because they reduce the amount of heat transferred across the air space by radiation. Reflective materials must always be installed in conjunction with an air space and do not have any insulating value if no air space is provided. Width of air space determines the efficiency of reflective insulation. The peak of efficiency is reached when the reflective surface faces a three-quarter inch air space. If the air space is greater or less than three-quarter inch, the efficiency is reduced. While it can be said that reflective insulation can stop 95% of the radiated heat, this does not mean that it will stop 95% of the total heat loss, because the other two channels of heat loss, namely, conduction and convection are not affected by reflection.

INSULATION VALUE OF AN AIR SPACE

In the past it has been quite common to call an enclosed air space a "dead" air space implying that there is no air movement in such a space. However, it is readily apparent from our previous discussion that there is always a movement of air due to convection if there is a difference of temperature between the two surfaces. The air in such a space is not "dead" because there is always considerable circulation of air within the stud space.

An air space does have some insulation value. The normal vertical air space of 3 5/8" is as good as 1/4 inch of an average insulation. If a reflective material is applied to one side of the air space it is equivalent to another 3/8" of an average insulation. Air in a wall built of 2 x 4's has a definite movement, however, and so does the air in any vertically enclosed space over an inch in width since there is always a movement of air due to convection if there is a difference of temperature between the two surfaces. The air in these spaces is not dead. On the contrary, there is always considerable circulation.

Tests made by competent authorities indicate that the effectiveness of an air space below three quarters of an inch is reduced until the air space is too small to have any appreciable insulation value. Laboratory tests also indicate that the insulating value of reflective air spaces decreases to a greater extent with increase in width beyond one inch than vertical non-reflective air spaces which are practically unaffected by a width beyond one inch.

DEFINITIONS

EXAMPLES OF HEAT TRANSFER - CONDUCTANCES OF WALLS

We have explained how and why insulation itself functions and how it prevents the transfer of heat in the walls, ceilings and floors of buildings. We now should go further and have some knowledge of the more common terms used in insulation advertising and engineering practice in order to be informed on how much heat may be transferred by various amounts of insulation so that you can recommend to your customers the most effective insulation for their particular requirement.

Relative Humidity. Relative humidity may be considered as the ratio of the amount of water vapor present at any given temperature to the amount the space could hold at that temperature if completely saturated. As an example, if a space of 1,000 cubic feet at 70°F contains .70 pound of water vapor the relative humidity will be $\frac{.70}{1.15} \times 100 = 61\%$, because such a space can hold a maxiumm of 1.15 pounds if saturated at this temperature. For a more comprehensive discussion of relative humidity reference may be made to the American Society of Heating and Ventilating Society's Guide. Relative humidity is discussed in Section V.

Btu. Btu is the abbreviation of British thermal unit and is the amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. The Btu is used to measure heat just as the inch or foot is used to measure length or as the minute or hour is used to measure time. There are 13,000 Btu's in a pound of coal, 141,000 Btu's in a gallon of oil or 1,000 Btu's in a cubic foot of gas.

"k" is used to show the amount of heat (Btu's) that will pass through one square foot of a specified material one inch thick for a temperature difference of one degree F between its two surfaces per hour.

Example: "k" of one inch of mineral wool blanket is .27. Suppose, for the sake of illustration, that the "k" factor of one inch of an insulating material is .28: this would mean that when the material is 1" thick .28 Btu are lost through one square foot of it per hour for each degree difference in temperature between inside and outside.

"C" represents the conductivity of a material and is used to show the amount of heat (Btu's) that will pass through a homogeneous material for the thickness or type under consideration per hour per square foot per degree F temperature difference between the two surfaces.

Example: "C" value of an 8 inch hollow concrete block is 1.00.

"U" is used to show the total or overall transmission of heat (Btu's) from air to air of a wall, roof or ceiling per hour per square foot per degree temperature difference between the two surfaces.

Example: "U" value of an uninsulated frame wall consisting of wood siding, wood sheathing, 2 x 4 studs, gypsum lath and plaster is .25. If insulated with one half inch of typical insulation the "U" factor would be .19, with two inches of typical blanket insulation, the "U" factor would be .095 and if insulated with three inches it would be .076.

The three measurements, "k", "C" and "U", as defined above should be understood in any discussion of insulating materials. When we talk of an individual material we refer to its "k" or "C" value. When we talk of a complete wall we refer to the "U" value. In considering these various factors it should be kept in mind that the lower the figure, the more the heat resistance. These values may be compared to a golf score - the lower the better. Some of the more common "U" values follow. For "K" values of the more common materials reference should be made to the ASHVE Guide or Technical Circular No. 7 of FHA.

● Every human being has his own built-in, personal heating system to keep him warm. The object of heating a house is to keep this body warmth from being drawn away too fast.

"U" VALUES OF COMMON WALL CONSTRUCTIONS
(Gypsum Lath and Plaster Interior)

TYPE OF WALL	No Insulation	1/2" Insulating Board Plaster Base	1/2" Blanket 2 Air spaces	1" Batt Blanket or Loose Fill	2" Batt Blanket or Loose Fill	3" Batt Blanket or Loose Fill	3 5/8" Wool
FRAME							
Wood or shingle siding							
1. With wood sheathing	.25	.19	.15	.13	.095	.076	.072
2. With insulating board sheathing	.19	.15	.126	.11	.084	.069	.064
VENEER							
Brick or Stucco on Frame							
1. With wood sheathing	.28	.20	.17	.14	.098	.078	.73
2. With insulating board sheathing	.20	.16	.13	.12	.087	.070	.066
8" HOLLOW TILE Stucco Finish	.26	.20	.15	.13	.096	.077	.072
8" SOLID BRICK	.31	.22	.17	.14	.10	.082	.076

"U" VALUES OF COMMON WOOD CEILINGS AND FLOORS

TYPE OF CEILING	No Insulation	Insulation Between or on Top of Joists									
		Insulating Board on Top			Blanket or Batts Between Joists				Vermiculite		
		1/2"	25/32"	1"	1"	2"	3"	3 5/8"	2"	3"	4"
Metal Lath & Plaster	.69	.26	.23	.19	.19	.12	.092	.067	.18	.14	.11
Gypsum Lath & Plaster	.61	.25	.22	.18	.19	.12	.091	.066	.17	.14	.10
Plywood	.59	.24	.21	.18	.19	.12	.090	.066	.17	.14	.10
1/2" Insulating Board Lath & Plaster	.35	.19	.17	.15	.15	.10	.082	.056	.14	.11	.091

"U" VALUES OF PITCHED ROOFS

TYPE OF CEILING	WOOD SHINGLES ON 1 X 4 STRIPS SPACED 2 INCHES APART						ASPHALT SHINGLES ON SOLID WOOD SHEATHING						SLATE OR TILE ON SOLID WOOD SHEATHING					
	Insulation Between Rafters						Insulation Between Rafters						Insulation Between Rafters					
	None	Blanket or Batt					None	Blanket or Batt					None	Blanket or Batt				
		½"	1"	2"	3"	3 5/8"		½"	1"	2"	3"	3 5/8"		½"	1"	2"	3"	3 5/8"
No Ceiling	.48	.21	.15	.11	.083	.069	.53	.21	.15	.11	.085	.069	.55	.23	.16	.11	.083	.069
Gypsum Lath and Plaster	.29	.19	.14	.10	.080	.067	.31	.19	.14	.10	.082	.068	.32	.23	.15	.10	.082	.068
Plywood	.29	.19	.14	.10	.080	.067	.30	.19	.14	.10	.080	.067	.31	.19	.14	.10	.082	.068
1/2" Insulating Board	.22	.15	.12	.090	.073	.063	.22	.15	.12	.090	.073	.063	.23	.15	.12	.093	.074	.063

SECTION III

WHEN AND WHERE TO INSULATE

Purpose of Insulation.

As mentioned earlier in this discussion the primary purpose of insulation is to keep the heat in or out of the building for as long as possible. We very often are asked, "How much insulation do I need to keep my house at 70°F?" The answer is that no insulation is required if you have plenty of radiators and boiler capacity and if enough fuel is burned in the furnace, but it will never be possible to have a wall and ceiling surface temperature at a comfort level without plenty of insulation. Perhaps one of the best examples of this is to mention some of the Army barracks used during the last war. In many cases coal stoves were burning maximum amounts of fuel yet if a person were more than ten feet from the stove he was cold. In summer they were hotter than out of doors. If sufficient insulation had been available for these buildings, a tremendous savings in fuel could have been realized and greater comfort obtained. We can therefore say that insulation permits the maintenance of desired air temperature as registered by the thermometer and a wall and ceiling surface temperature conducive to comfort at the lowest possible fuel cost in winter. Thus it is performing its winter purpose. Its summer purpose is to maintain indoor comfort by keeping the wall and ceiling surface temperatures lower than the outdoor temperature.

Some buildings cannot be properly heated with their present heating equipment, due to enlargement or to more modern ideas of comfort or to old heating equipment. With a reduction in fuel consumption up to 30% or 40% by a full job of insulation in an existing building, comfort can be restored and existing equipment made to function satisfactorily.

In addition to saving fuel the comfort of an insulated house in cold weather should always be considered. You have all been in rooms where the thermometer reads 70 degrees but where you feel chilled. The odds are that the home was uninsulated and that the heat from your body was being drawn too rapidly to the colder surfaces. The same thing, only to a faster degree, occurs if you sit on a cold metal chair. Heat is drawn from the body to the chair. In a room with cold walls body heat is drawn to the cold walls. The use of insulation will materially reduce the loss of body heat, by keeping the walls warmer.

While we have paid a great deal of attention to the economic value of insulation due to the savings in fuel in winter we should also keep in mind that a large amount of insulation is purchased purely for the sake of summer comfort. The economic value of comfort though very real cannot be readily reduced to dollars and cents and therefore cannot be expressed in the usual economic terms. However, insulation contributes greatly to summer comfort and insulation plus provisions for ventilation should always be considered where warm or high outdoor temperatures are experienced.

If you have ever climbed onto the roof of a building in summer you have experienced the surprisingly high temperatures which occur on the roofing material. These temperatures will go as high as 140 degrees. If we are trying to keep the inside of the house at 70 degrees the use of insulation for comfort can be appreciated. If the roof or ceiling is not insulated, the heat easily penetrates the rooms below. Even with insulation some of the heat will get into the attic. The attic, if not ventilated, will eventually act as a heat storage reservoir. The solution of course is to keep the attic ventilated. Cross ventilation is desirable and should be at the highest part of the attic preferably near the ridge line, by the use of permanent louvres or vents.

METHODS OF INSULATING

There are three ways of retarding the passage of heat by the use of insulating materials:

(1) *By replacing* materials having a high rate of heat conduction with materials having a low rate of heat conduction. Example: Using insulating board sheathing and lath in place of non-insulating sheathing and lath.

(2) *By adding* insulating materials to the wall to partially or completely fill the air space. Example: Any type of batt, blanket or fill insulation placed in the wall or ceiling.

(3) *By applying* a reflective insulation to one or both surfaces of the air space or adding one or more reflective membranes in the stud space. Example: Adding a layer of aluminum foil to the back of the plaster lath.

WHERE TO INSULATE

1. *New Construction.*

(a) *Homes with unused attics.*

The general rule to follow is to insulate the walls, ceilings and floors immediately surrounding the area to be heated in winter. If the attic is not used then the insulation should be placed in the attic floor. This is preferred to insulating the roof as less material is required, since only the used portion of the building is heated and ventilation of attic space becomes a simple problem. Exterior walls should always be insulated.

(b) *Attic Rooms.*

Insulate the walls and ceilings around attic rooms following the outline of the room. If there is other attic space not enclosed the attic floors of the unused portion should also be insulated.

(c) *Houses without Basements.*

Many of today's homes are being built without basements or with basements under only part of the building. A good many builders prefer a crawl space under the floor rather than placing floor on the ground. When a crawl space is used it is recommended that insulation be placed in the floor. Good practice also calls for ventilation of the crawl space to protect against the effects of dampness.

(d) *Rooms over Open Porches.*

The floors of rooms above open or unheated porches or garages should be insulated in addition to all wall and top floor ceiling areas.

2. *Remodeling.*

(a) *Attic Rooms.*

If additional rooms are being built into the attics of existing houses the outside walls and ceilings should be insulated. Follow the outlines of the rooms in applying the insulation. This is preferable to insulating the roof line as ventilation can be placed in the uninsulated hip of the roof.

(b) *Basement Rooms.*

Where a basement space is to be remodeled into a room, insulation of floors and walls is recommended. In addition to savings in fuel, insulation may be used on the ceiling to reduce the passage of sound from the basement room to other parts of the house.

(c) *Additions.*

When rooms are added to a house or porches are enclosed to make extra room the walls and ceilings should be insulated the same as in new construction. If the area beneath this addition is not heated the floor should be insulated. When porches are made into year round rooms, proper insulation will often make the addition of a heating unit unnecessary.

WHERE HEAT IS LOST OR GAINED IN A BUILDING

Studies of various typical buildings as to relative heat loss and gain through various parts of the house are given below. These values are not for the same house but are typical enough to be indicative of heat transmission:

Heat Loss in Winter		*Heat Gain in Summer*	
Walls	32.9	Walls	33.6
Ceilings and Roof	22.2	Ceilings	24.2
Floors	.3	Floors	3.7
Glass and Doors	29.9	Glass and Doors	26.4
Infiltration	14.7	Infiltration	12.1
	100.0%		100.0%

The above figures were based on typical two story homes. It is readily apparent that insulation in walls and ceilings will stop the greatest heat losses. Double glazing or storm windows and doors will materially reduce the heat loss.

The percentages would vary somewhat on one-story houses as the ceiling area would proportionately be greater and the wall area less.

FUEL SAVINGS

Any general statement of the amount or percentage of fuel that can be saved due to insulation is likely to be inaccurate. However, the amount of fuel that can be saved annually in any specified instance by the application of a certain type and thickness of insulation can be estimated in advance with considerable accuracy. To do this it is necessary to know the type of construction to be insulated, the area of the surface to be insulated, the location of the building and other factors. A simple example will illustrate how it is possible to estimate the amount of fuel that can be saved.

Let us assume that a residence is to be of frame construction with walls consisting of wood siding, building paper, wood sheathing, studding and lath and plaster. The "U" value of this construction is 0.25 Btu per hour per square foot of wall surface for each degree temperature difference. If, however, a one inch thickness of blanket insulation is added to a wall of this construction, the rate of heat loss will be reduced to 0.13 Btu, or a saving of 0.12 Btu per hour for each square foot insulated. These figures can be obtained from the Guide of the ASHVE and other recognized authorities.

Now assume that the net wall area to be insulated is 1,000 square feet, in which case the saving would be 0.12 times 1,000, or 120 Btu per hour per degree temperature difference. Next suppose that this building is located where the average outside temperature during the heating season is 35 degrees and where the heating season extends approximately from October 1st to May 1st, or 5,088 hours. This is the approximate average temperature of Baker, Oregon, or Albany, N.Y. Based on an inside temperature of 70 degrees F, the temperature difference will be 35 degrees and the heat saving will therefore be 120 times 35 times 5,088, or 41,400,000 heat units (Btu) per heating season. See the table following for fuel values and heating efficiencies.

This quantity would, of course, be meaningless to the average person and must therefore be translated into tons of coal, gallons of oil or cubic feet of gas, by dividing the heat content of the fuel and the assumed heating efficiency. For estimating purposes the fuel heat contents and heating efficiencies in the following table may be used for average conditions.

In this example assume that the fuel is coal having a heat content of 13,000 Btu per pound and an overall heating efficiency of 50%. The fuel savings will then be: $\frac{21,400,000}{13,000 \times 50}$ = 3290 pounds = 1.64 tons of coal.

(See chart next page)

FACTORS FOR ESTIMATING ANNUAL FUEL SAVINGS DUE TO INSULATION *

FUEL	METHOD OF FIRING OR TYPE OF APPARATUS	ASSUMED CALORIFIC VALUE OF FUEL	ASSUMED HEATING EFFI-CIENCY	FUEL SAVING FACTOR (per 0.01 Btu dif.)	RESULT (ANNUAL FUEL SAVINGS)
Coal	Hand-fired (residence)	13,000 Btu per pound	0.50	0.137	Tons of Coal
Coal	Stoker-fired (residence)	13,000 Btu per pound	0.60	0.114	
Oil	Conversion Burner	141,000 Btu per gallon	0.60	21	Gals. of Oil
Oil	Oil-designed Unit	141,000 Btu per gallon	0.85	15.75	
Mfd. Gas	Conversion Burner	535 Btu per cubic foot	0.65	5.12	1000 cu. ft.
	Gas Designed Unit	535 Btu per cubic foot	0.80	4.16	
Nat. Gas	Conversion Burner	1000 Btu per cubic foot	0.65	2.74	1000 cu. ft.
	Gas Designed Unit	1000 Btu per cubic foot	0.80	2.23	

* These factors give the approximate annual fuel saving per 1,000 sq. ft. of insulated area per 0.01 Btu per sq. ft. difference in the U value with and without insulation and for an average inside-outside temperature difference of 35 degrees. Example: For oil fuel and a conversion burner the fuel saving will be 21 gals of oil per heating season per 1000 sq. ft. of insulated area per 0.01 Btu difference in the heat loss coefficients $(U - U_i)$ with and without insulation and for an average temperature difference during the heating season of 35 degrees. If $(U - U_i) = 0.10$, the annual fuel saving will be 10 x 21, or 210 gallons and for any other average temperature difference or insulated area, the fuel saving will be in direct proportion to the temperature difference and area.

HEATING AND COOLING PLANTS

The size of the heating plant is of course reduced in the proportion that the heat losses are reduced. In many cases this will permit the use of a smaller heating plant, including smaller radiators and accessories, which will result in a monetary saving which may be applied against the cost of the insulation. In extreme cases, the saving in the cost of the heating plant including radiators, is sufficient to offset the added cost of the insulation. Thus the annual fuel saving is obtained without cost. If the insulation does have a definite net cost, as is usually the case, the fuel saving pays an attractive return on the investment, which continues as long as the building is heated.

When summer air conditioning systems for comfort are installed similar reductions in equipment may be made by the use of insulation. An insulated building will not require as large a system and the operation time will be reduced as the variations in temperature will not be as great as in an uninsulated building. It should also be pointed out that electrically powered equipment is expensive to operate. Less operating time will result in considerable dollar savings. It is generally estimated that the cost of reducing indoor temperatures 1° in summer is eight times the cost of increasing the temperature 1° in winter.

There are three possible heating plant savings with steam, hot water and vapor systems, namely: (1) reduction in the amount of radiation required in each room or space to be heated, (2) reduction in the size of the boiler or furnace required and (3) smaller sized stoker, oil burner or gas burner where automatic fuel burning equipment is used.

INSULATION AS AN INVESTMENT

The increased public demand for heat resistive construction in post war houses indicates that the average home owner is well aware of the dollar savings due to insulation and that insulating materials may be considered in much the same light as stocks and bonds in that they return or pay a certain dividend every year.

We can easily arrive at this yearly dividend or return on an investment of insulation by using the example shown above for Fuel Saving. The return would of course depend on the cost of the insulation and the dollar value of the fuel saved. We previously found that our fuel saving in coal was 1.64 tons. If we assume a cost of $15.00 per ton, the annual saving would be $24.60 for the 1,000 square feet of area to be insulated. Let us assume that the installed cost of the insulation is $75.00 for the 1,000 square feet. The annual return would be

$$\frac{100 \times 24.60}{75.00} = 32.9\%$$

When it is considered that most houses are purchased with only 10% down payment, the value of this estimate becomes immeasurably greater. This is because with the type of insulation described in this example, the initial cost to the home owner should be only 10% of $75.00 or $7.50. With more expensive insulation, the savings would be greater but the out-of-pocket expense would amount again to only 10% of the initial cost.

ECONOMIC THICKNESS OF INSULATION

The question always arises as to how to determine the proper thickness of insulation or how to arrive at the most economic thickness. If insulation is justified, just how much? Insulation literally offers something for nothing because in almost every case it eventually will pay for itself in the fuel it saves. However, there may be an understandable doubt regarding the economics of insulation because claims have often been presented in such general and all inclusive terms as to be unbelievable.

A man reads in one place that building insulation will save 30% of his fuel bill; in another that double glazing or storm sash will save 30% and in still another that weatherstripping may save 20% to 30%, and then he learns that if he uses a modern type of heating plant he can further reduce his fuel bill by 20% to 30%. He adds these figures and finds that the four claims total 120% saving. This is manifestly impossible, or else he would have to put refrigeration in his house in winter in order to keep the house cool enough to live in. This method of calculation has often been the subject of jokes, and it is because you cannot add these savings in terms of percentages. Suppose the building insulation will save 30% as illustrated above and the fuel consumed would otherwise have amounted to ten tons of coal; the coal consumption will now be 30% less than 10 tons or 7 tons. If then, double-glazing or storm sash, as illustrated above, save another 30%, the saving is 30% of the 7 tons, or 2.1 tons, or a consumption of 4.9; you never can get down to using no coal at all. However, savings of these amounts have occurred in individual buildings, and total savings of over 70% are theoretically possible. Usually under the best circumstances, the savings do not exceed 50%, although in some instances they do run that high by using every fuel-saving device.

The variable factors which affect the investment return on insulation and make the choice of insulation an individual problem point out why it is necessary to have different types and thicknesses for different climates, different fuel costs and different types of buildings. Obviously, the owner of a home in Minneapolis can afford to invest more in insulation than the owner of the same home in Baltimore, if both expect to pay the cost of their investment in the same length of time.

There are other factors, too, which make it desirable to offer insulations having various degrees of effectiveness. Along with insulation the owner may want to get decorative effects, or he may want to insulate at maximum economy so that his insulation may have a structural value, or the builder may be erecting a home for rent where the tenant may be required to furnish his own heat. Such circumstances would warrant the use of an insulation particularly adapted to such requirements.

On the other hand, there is the builder or home owner who is not so much concerned with the total investment or the annual operating cost of his heating equipment. He wants comfort, and a great deal of it. In such cases he will gladly pay for maximum insulation. If he wants comfort in summer as well as winter, economics must be disregarded in favor of maximum results.

SECTION IV

COMMERCIAL BUILDING INSULATIONS

TYPES, USES, APPLICATION, TYPICAL MATERIALS

TYPES OF BUILDING INSULATION

I. Loose Fill Insulations
  A. Fibrous
    1. Mineral wool
      a. Rock wool
      b. Glass wool
      c. Slag wool
    2. Vegetable Fiber (wood)
  B. Granular
    1. Mineral (e.g. Vermiculite)
    2. Vegetable (e.g. Granulated cork)
II. Blanket Insulations
  A. Wood fiber or mineral fiber lined or wrapped one or both sides with paper.
  B. Multiple layers of asphalt treated wood fibers stitched to creped cover and compressed for shipment.
III. Batt Insulations
  A. Plain (no vapor barrier)
  B. Vapor barrier on one side, plain on other
IV. Structural Insulating Board
  A. Building Board
  B. Sheathing
  C. Lath
  D. Tileboard (panels)
  E. Plank
  F. Roof Insulation Board
V. Slab (or Block) Insulations
  A. Corkboard
  B. Wood fiber and cement
  C. Mineral wool with binder
  D. Insulating board slabs
  E. Asphalt-Vermiculite slabs
  F. Hard rubber
  G. Cellular Glass
VI. Reflective Insulations
  A. Aluminum foil
    1. Plain (no paper backing)
    2. Paper backed foil
  B. Aluminum foil-surfaced plaster board
  C. Dull sheet steel
VII. Miscellaneous
  A. Confetti-like material sprayed on with adhesive (e.g. Spray-O-Flake)
  B. Combinations of aluminum foil with other types of insulation such as blankets and structural insulating board.
  C. Insulating board core surfaced on one or both sides with asbestos-cement board, metal or other material (e.g. Cemesto)
  D. Multiple layers of corrugated paper
  E. Cellular mass made from liquid resin (e.g. Textolite Foam).

Preparation.

A job is no better than the man who installs it.

Insulating materials must be properly installed if they are to perform efficiently. If a material is improperly applied, the value of the insulation may be greatly diminished or even completely nullified. For example, if a reflective insulation were installed so that the reflective surface were covered or were in contact with another material, the insulating value would be entirely voided. Most manufacturers supply detailed specifications or application instructions covering the proper application of their products.

One of the major causes of complaints received by the manufacturer is due to the fact that application instructions as supplied to the lumber dealer are not followed on the job. The manufacturer, by the nature of his position, is the most informed person on how and where to apply his material. In order to get the most use and efficiency out of it, the lumber dealer and his staff should study the instruction sheets and other material circulated by the manufacturer. When purchases of an insulating material are made, the dealer should make a practice of explaining how the material should properly be used. Such practice will stop a great many unnecessary complaints and add to the dealers prestige.

1. LOOSE FILL INSULATIONS

Description

Fill insulations are bulk materials which are usually sold in bags. Various types may be packed, poured or blown into open framing members.

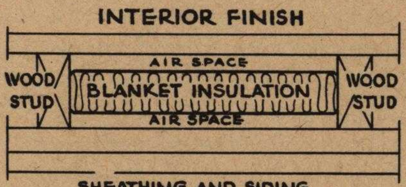
Mineral Wool includes three types of incombustible insulation called rock wool, slag wool or glass wool, depending upon the nature of the material from which it is manufactured. Rock wool is made from rock; slag wool is made from slag. In both cases, they are melted in a high cupola with a hole at the bottom to let a molten stream of the material out. This passes through a blast of steam that blows the material into long hair-like "wool" threads, which, on cooling in the air, fall to the floor of a collecting chamber. From this first formation they may be fabricated into nodules or into batts or blankets. Glass wool is produced by melting glass sand and passing the molten mass through tiny orifices where, upon cooling, it is fabricated in a manner similar to that of other mineral wools.

Mineral wool-filled bearing partitions have been accorded a one-hour fire rating when faced with metal lath and plaster.

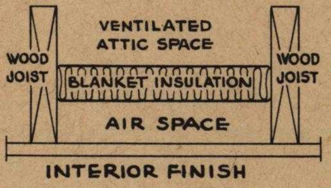
In some cases loose mineral wool is poured from bags into framing members where the space is accessible and it is practical to do so. More often it is blown into open and concealed spaces, such as unfloored ceilings or walls, by a blowing machine such as those already acquired by many lumber dealers. This machine is like a vacuum cleaner in reverse, and will produce a more uniform and more compact job than can be obtained by hand methods. The machine takes the material through a hose into spaces prepared for its reception. These spaces may be entirely concealed, such as the stud spaces in walls of existing houses where plaster is also already in place.

Wood Fiber Wool Fill Insulations. There are several fill insulations made from wood fiber into a light-weight fleecy insulating material. These are gener-

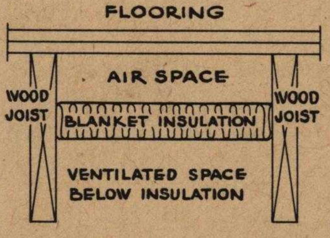
APPLICATION OF WOOD FIBER INSULATION



WALL SECTION



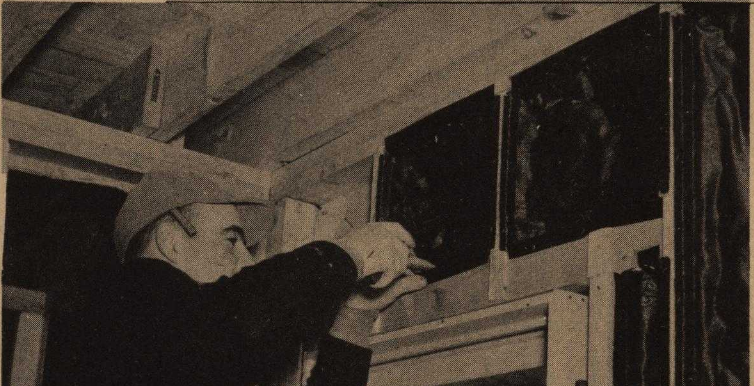
CEILING SECTION



FLOOR SECTION

1

2



3

1. Wood fiber blanket insulation installed over ceiling areas.

2. Wood fiber blankets cut on job to any length required.

3. Installation in wall showing how it can be cut to insulate irregular spaces.

COURTESY OF WOOD FIBER BLANKET INSTITUTE

ally treated to render them vermin repellent and moisture resistant. Some are also fire resistant. This type of insulating material is also fabricated into blanket insulations.

Vermiculite is an inert, light-weight, granular insulating material manufactured by exploding an aluminum magnesium silicate mineral, which is a form of mica. This mineral is made up of approximately one million separate layers per inch. Between each layer is a minute amount of water. When flakes of the mineral are suddenly exposed to high temperatures in a specially designed furnace, the water between the layers changes to steam, causing it to explode into cellular granules or vermiculite insulation about fifteen times their original size. The final product is graded into different sizes for various uses, including building insulation, light-weight concrete and plaster aggregate.

USES

Fill type insulations are normally used for insulating existing buildings by a blowing-in process. Some types are poured in open attics between ceiling joists. Some materials of this type may also be installed by hand packing in irregular spaces. Typical installations are floored or open attics, wood, stucco and brick veneer walls.

APPLICATION OF FILL INSULATIONS

The application of granulated type fill insulations, such as expanded vermiculite (mica pellets), loose and granulated rock wool is comparatively simple. The material is poured from bags in which it is sold, or hand-packed (in the case of loose fill), or blown from a blowing machine between the framing members. Vermiculite is generally used between ceiling joists only.

Insulating Walls with Fill Insulation.

The pneumatic method of installation is the most common because it produces a pressure when properly adjusted so that all the spaces are packed full. This method can be used during or after the completion of the construction. Loose or nodulated rock wool or similar fibrous materials can be hand-packed as the construction proceeds, but only expert and careful mechanics can be depended upon to get uniform density and complete filling.

If a vapor barrier is to be provided, it should be installed on the warm side of the wall that is, on the inside of the studs, and nailed thereto. The barrier should be installed as the work progresses, starting at the bottom of the wall, and applying first the vapor barrier and then the plaster base or interior finish over it to a height of not to exceed 48 inches. The fill insulation may then be poured from the bags, or hand packed in the case of loose rock wool, to this height, and the procedure repeated until the stud spaces are filled to the top.

Insulating Ceilings with Fill Insulation. Loose fill insulations of the granular or fibrous types may also be poured from bags into the spaces between the ceiling joists to the desired depth, usually four inches. The fill insulation may be poured in place as soon as the plaster base or interior finish is installed, except where open lath are used, in which case it is necessary to wait until the plaster has been applied and has thoroughly dried.

If a vapor barrier is to be provided it should be installed on the under side of the ceiling joists before the interior finish is applied. The fill insulation will, when installed in accordance with the foregoing procedure, rest directly on the upper surface of the barrier.

Pneumatic Method of Application. The problem of insulating existing buildings will fill insulation is more intricate, due to the lack of access to the hollow spaces in walls and roofs. This is accomplished successfully by blowing nodulated or granulated mineral wool between these spaces. The wool is blown through a hose under pneumatic pressure, the installation being done by applicators equipped with the special apparatus for doing this work. Many lumber dealers own their own blowing machines and do a large and profitable business in this field. Others make mutually satisfactory financial arrangements with specialists and make no investment in such equipment.

The use of a vapor barrier in existing structures is not mandatory, but is a good insurance against housekeeping methods that result in high humidities, such as allowing the drying of laundry indoors, over-use of humidifying apparatus, or permitting damp basements. It is advisable to provide ventilation over ceiling insulation in all cases where high interior humidities would otherwise develop. An efficient vapor barrier may be provided by applying two coats of lead and oil or aluminum paint to the interior plaster surface, but ventilation and control of humidity normally are sufficient. If aluminum paint is used to provide a vapor barrier it can be covered with any type of decoration

2. BLANKET TYPE INSULATIONS.

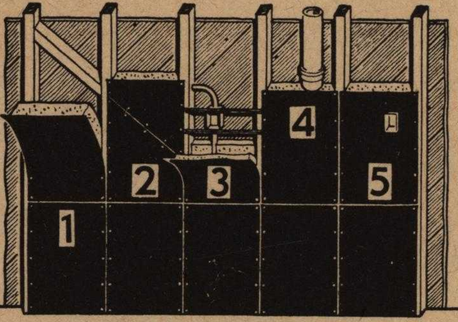
Description

Blanket Insulations are flexible insulations over 48" in length, manufactured to controlled thicknesses. Blankets are folded into cartons or rolled into rolls. Strips is another name for blankets. They are made from various processed mineral wool and vegetable fibers and animal hair, including mineral wool (rock, glass, and slag), wood fiber, cotton and cattle hair. The fibers in most cases are either naturally fire, moisture and vermin-resistant or are treated to render them so.

Because of the variation in the different products, the manufacturing processes vary considerably. Blanket insulation, however, may be considered as being of felted or wool-like mattings which are of three general types: (1) those having the fibers completely encased on all sides with kraft or other paperm one side of which is a vapor barrier, and (2) those that have a vapor barrier paper on one side only and are not encased. (3) Those that have no paper covering, the interlaced fibers having sufficient strength with or without stitching, to hold the material into a coherent matting or blanket.

Materials in the first two classifications often are provided with a nailing flange to conform to standard spacings of wood framing. Those in the second classification are usually made enough wider than the standard framing spaces to provide for edge fastening through the material itself. The most common thickness of mineral wool blankets is a three inch nominal thickness but blankets are also made one inch and 2 inches thick. These thicknesses are not always specified but are called various names by competing manufacturers, such as full-thick, double-thick, standard, commercial, etc.

DETAILS OF MINERAL WOOL INSTALLATION



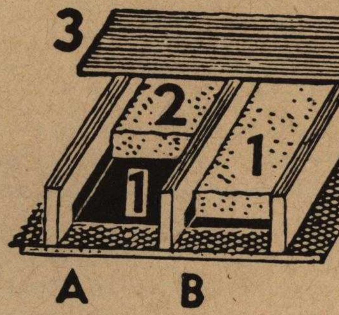
1. Start at bottom of stud space, installing Mineral Wool below floor line for fire-stopping. Completely insulate each stud space, snugly butting successive batts together and fastening the flange of vapor barrier to the studs. Where required at sills, plates, etc., provide additional flange on the vapor barrier by cutting away the wool but leaving vapor barrier for overlap on framing.

2. Cut batts to fit angles, corners and irregular spaces, leaving flanges on the vapor barrier for fastening.

3. Where electrical cables or conduits obstruct the panel, split the batts and install part of the wool behind the obstructions, placing the remainder over the face.

4. Large pipes may require removal of part of the wool, but retaining the vapor barrier. To protect water pipes from freezing, apply insulation to the cold side only, removing it from the batt where the piping is located but leaving the vapor barrier intact.

5. Cut vapor barrier to fit snugly around electrical outlets, protruding pipes, etc.

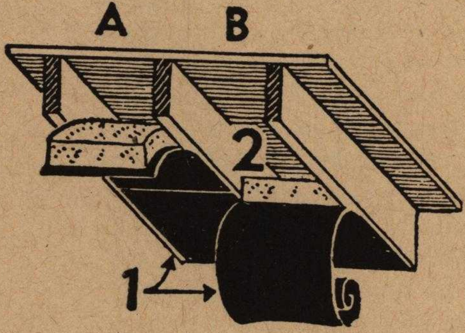


A. Batts Without Integral Vapor Barrier

1. Where a vapor barrier is required, install it directly on top of ceiling.
2. Place batts down on the vapor barrier, butting them closely together, completely insulating each space. Where no vapor barrier is required, place batts directly on top of ceiling.
3. Install flooring as required.

B. Batts With Integral Vapor Barrier

1. Install insulation with vapor barrier down against top of ceiling, completely insulating each joist space and butting batts closely together.
2. Install flooring as required.



A. Batts and Blankets With Integral Vapor Barrier

1. Insert from below, tightly butting batts together and attaching flanges of vapor barrier securely to joists before applying support. Completely insulate each joist space.
2. Cut blankets to required length plus allowance for attaching at ends.

B. Batts Without Integral Vapor Barrier

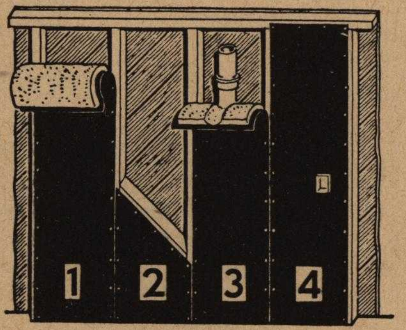
1. Where a vapor barrier is required, install it by attaching to the under side of joists before applying lath, wall board or other support.
2. Insert batts progressively as vapor barrier and support are applied. Fit batts tightly against those already installed. Continue till each joist space is insulated completely.

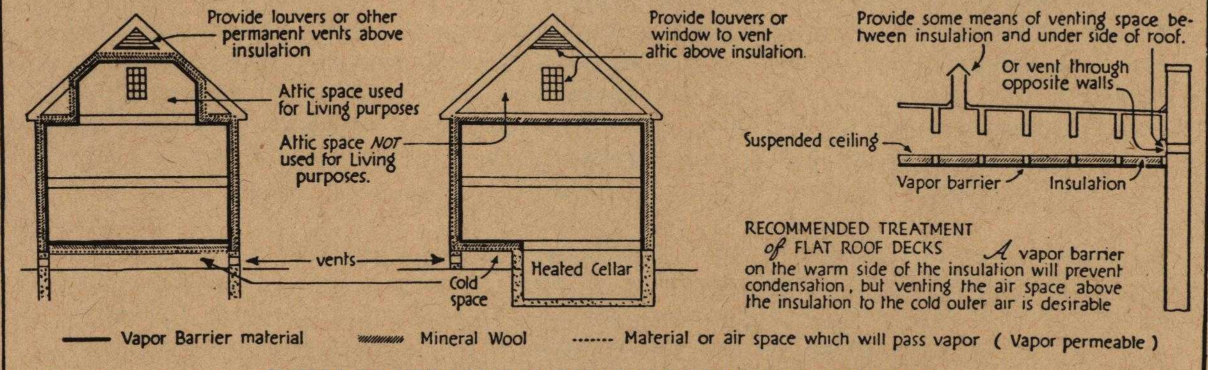
1. Cut continuous strips to the required length for each stud space, allowing sufficient length for installation below floor line for fire-stopping and for attachment at top and bottom. Completely insulate each stud space, fastening the flanges of the vapor barrier to the studs.

2. Cut strips to fit angles, corners or irregular spaces, always providing a flange on the vapor barrier for fastening.

3. Large pipes may require removal of some of the wool, retaining the vapor barrier. To protect water pipes from freezing apply insulation on the cold side only removing it from the strip where the piping is located but leaving the vapor barrier intact.

4. Cut vapor barrier to fit snugly around electrical outlets, protruding pipes, etc.




Provide louvers or other permanent vents above insulation
Attic space used for Living purposes
Provide louvers or window to vent attic above insulation.
Attic space NOT used for Living purposes.
vents
Cold space
Heated Cellar
Provide some means of venting space between insulation and under side of roof.
Or vent through opposite walls
Suspended ceiling
Vapor barrier
Insulation
RECOMMENDED TREATMENT of FLAT ROOF DECKS
A vapor barrier on the warm side of the insulation will prevent condensation, but venting the air space above the insulation to the cold outer air is desirable
Vapor Barrier material
Mineral Wool
------ Material or air space which will pass vapor (Vapor permeable)

WHERE TO USE MINERAL WOOL INSULATION IN BUILDINGS

With Proper Relationship of Vapor Barriers and Vapor Vents

Courtesy of NATIONAL MINERAL WOOL ASS'N.

USES

Blanket type materials are usually installed where there are large areas requiring insulation. Blanket materials are sold in long pieces (40' to 100' depending on thickness) which can easily be installed where a minimum of cutting and fitting is required. They can be used in side walls of new buildings, in attics and roofs and can be recommended in remodeling work where an extra room is added to the home.

APPLICATION OF BLANKET TYPE INSULATIONS

Masonry Walls. Blanket insulation may be installed where the thickness of the furring strips prevents contact of the insulation with rain borne moisture conducted to the back side of the masonry. Wherever insulating blankets or batts are used with new masonry, an effective vapor barrier should be installed on the warm side of the insulation to reduce the passage of vapor. The small amounts of vapor which penetrate the wall will pass to the outdoors through the masonry which is always vapor permeable.

In order to apply blanket insulations to masonry walls it is necessary first to install furring strips vertically and the proper distance apart, usually 16 inches on centers. The furring strips usually are either 1 x 2 or 2 x 2 inch wood strips and are attached to the masonry walls by securely anchoring them to the wall. Where the wall is of solid concrete, it is necessary to drill holes in the concrete and to attach the furring strips by means of expansion bolts. The furring strips not only serve to level off the wall and provide a means of attachment for the blanket insulation, but also separates the insulation from the masonry by an air space, thus preventing any dampness from entering the insulation. Many blanket insulations are enclosed in a waterproof material which would protect them from such dampness.

The insulation is then nailed or tacked in continuous strips to these furring strips. The ends of the insulation are fastened to sills, plates or headers in a similar manner. If an interior finish is to be installed, as is usually the case, the blanket insulation need only be tacked to hold it in place until the interior finish is applied. Blanket insulation having a nailing flange may be installed in a similar manner, the nails or tacks being driven through the flange into the furring strips. Compressible type blankets may also be run over the framing and compressed beneath the lath or interior finish. This method is often used by prefabricators or mass builders.

Frame Construction. There are two methods of applying blanket insulation to frame construction: (1) between the framing members, or (2) on the face of the inside edges of the framing members.

Between Framing Members. When applied between framing members, blanket insulation of less than the thickness of the framing members should be installed in such a manner that two air spaces are formed. The insulation is held in place by means of lath strips nailed through the insulation into the sides of the framing members. The ends are similarly fastened in place to the header or plate and sill by means of lath strips. Where nailing flanges are provided, nailing is made through them to the framing members.

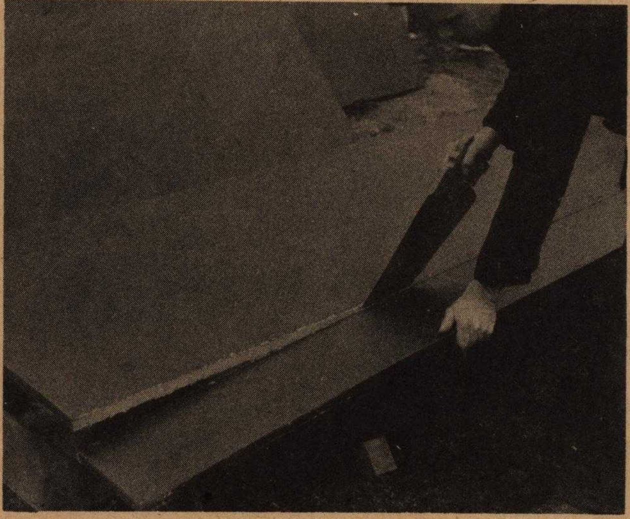
Many thin insulations are attached to the face of the studs.

One type of flexible insulation is installed between studs by first securing

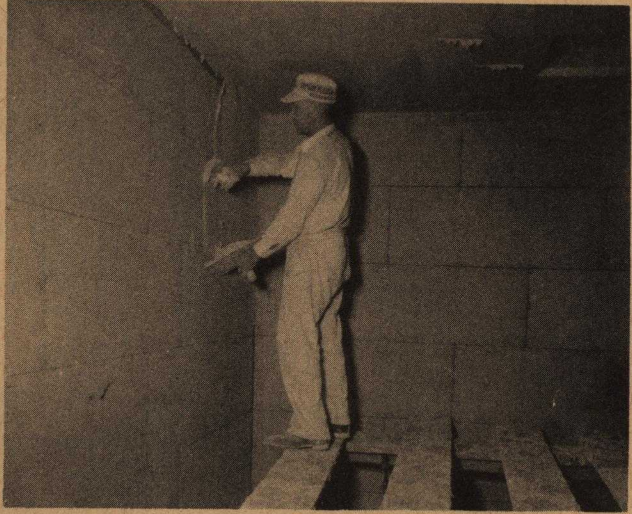
APPLICATION OF STRUCTURAL INSULATING BOARD

SHEATHING - small pieces used over doors and windows - reduces waste.

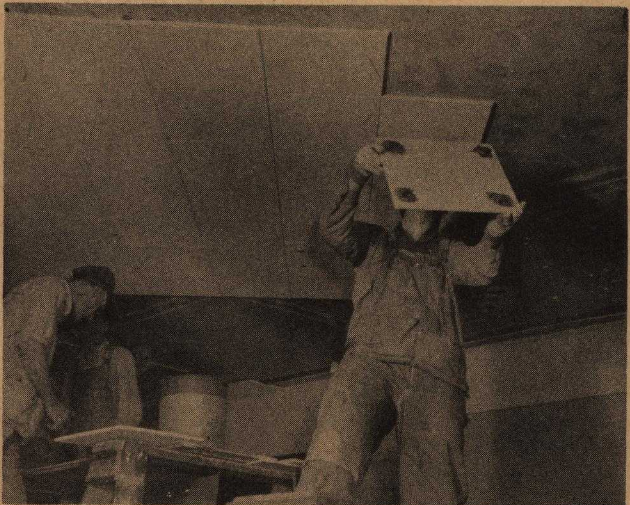
2 ft. x 8 ft. asphalt coated sheathing applied to frame wall - light weight permits easy handling



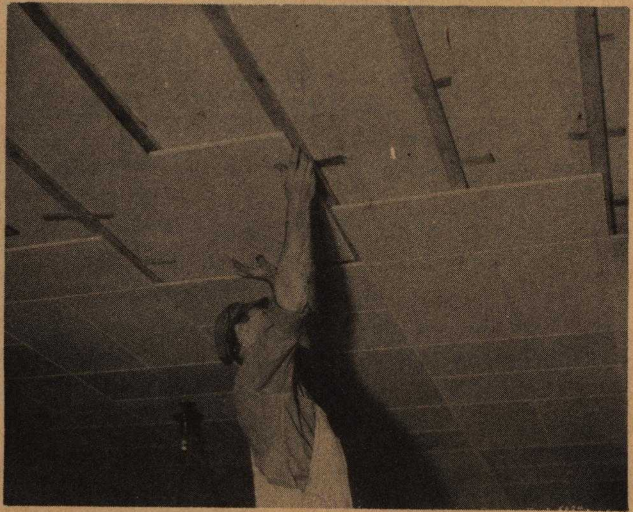
All insulating board materials can be cut with ordinary tools.



Insulating lath showing one type of edge reinforcing.

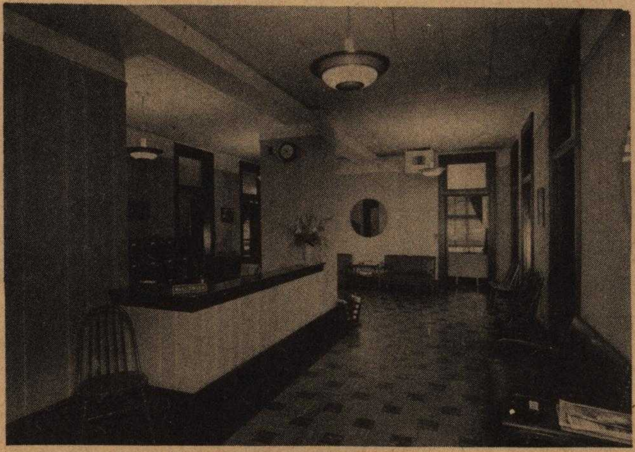


Decorative insulating tile being applied with adhesive.

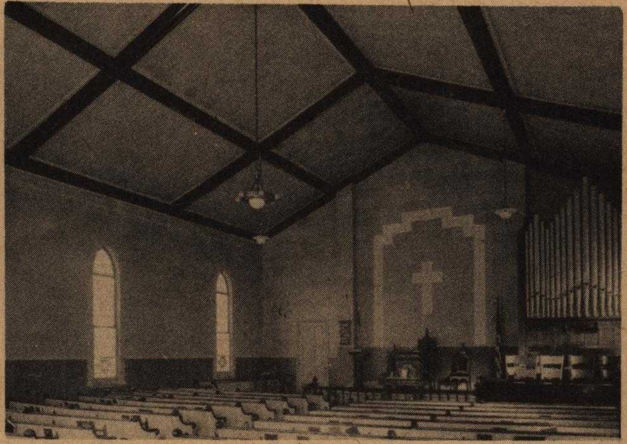


Installation of insulating tile on furring strips, spaced 16" o.c.

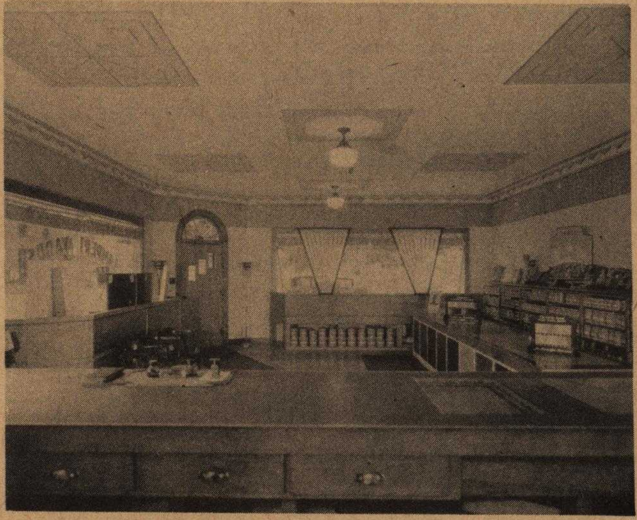
DECORATIVE INSULATING BOARD IN VARIOUS TYPE INTERIORS



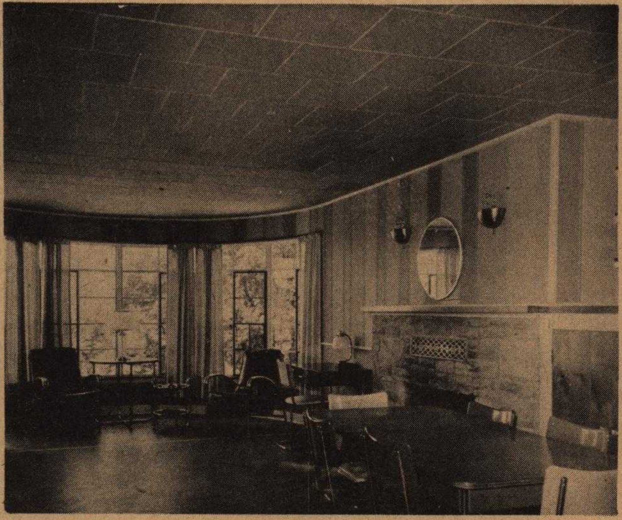
OFFICES AND RECEPTION ROOM - Random Plank on walls square tile on ceiling.



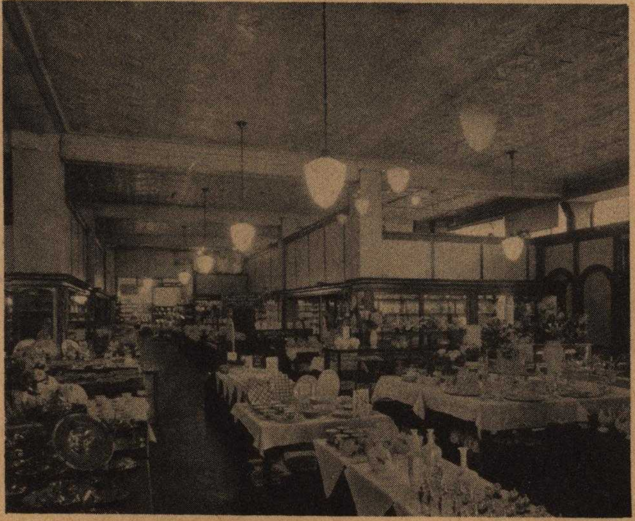
CHURCH - Rectangular Tile in Ashlar Pattern on side walls - Square Tile in ceiling.



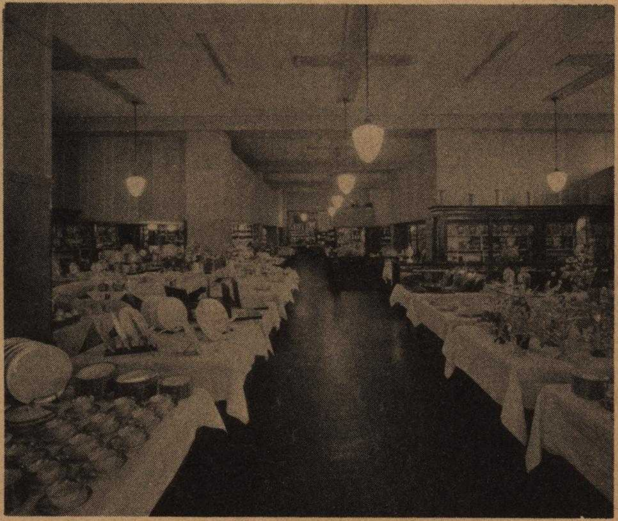
LUMBER YARD SALES ROOM - plank on walls with Decorative Cornice - Square Tile on ceiling.



RESIDENCE - Random Plank on Walls - Rectangular tile in ceiling.



RETAIL STORE - Before remodelling with decorative insulating board.



RETAIL STORE - After remodelling with Insulating tiles and plank.

the end with lath strips to the header, then stretching to the desired length and attaching to the sill in the same manner, after which the blanket is fastened along the sides near the studs by driving nails at intervals of approximately 18 inches through the edges of the insulation into the sheathing.

Over Inside Edges of Framing Members. As previously stated, certain types of blanket insulation are provided with flanges for nailing to the framing members. The folded portion of the flange is lapped over the exposed edge or face of the framing members and tacked or stapled through the flange for temporary fastening until held permanently by the plaster base or interior finish. If the interior is not to be finished, wood strips are applied over the edge of the framing and ends should be nailed to sill, plates or headers.

3. BATT TYPE INSULATIONS

Description

Batt insulations are similar to blankets except that they are 48 inches in length or under. The most common thickness of mineral wool batt insulation is wall-thick (3 inches) and may be completely encased in all sides with paper, one side of which is a vapor barrier, or may have a vapor barrier paper on only one side. Batts are manufactured in widths suitable for inserting between framing - usually about 15 inches wide for framing on 16 inch centers and 23 inches wide for 24 inch centers. Batts are also furnished in 1 inch and 2 inch thicknesses.

USES

Batt and blanket type materials are interchangeable in all areas. The decision as to which type to use depends on the customer's preference.

APPLICATION OF BATT TYPE INSULATIONS

Batts - (With vapor barrier paper attached)

Batts are installed by inserting them between the framing members and fitting them tight against studs and sheathing. Adjoining batts are butted snugly together and the nailing flange nailed or stapled to the face or side of the framing member. Odd shaped spaces are filled by cutting batts to the proper size.

Batts - (Without Vapor Barriers)

A vapor barrier is recommended where plain batts are used and is applied on the warm side of the wall as soon as the batts are in place.

4. INSULATING BOARD

General Description

Structural insulating boards are made primarily from wood or vegetable fibers. Although the methods of manufacture vary somewhat, the first step usually is to take the raw material and make it into a pulp, after which the fibers are washed and waterproofed. They are then felted together and formed into large sheets. The boards are then dried, cut and trimmed to the finished size.

The outstanding feature of insulating board is that it combines structural strength with insulating qualities.

During the felting process, millions of tiny air cells are trapped between the fibers, which give the boards their insulation value.

(a) BUILDING BOARD

Description

Building board is a square edged insulating board normally furnished in 4 foot wide sheets and in various lengths. Most of the boards have a finished surface which does not require further decoration. Some manufacturers also furnish the material with a painted surface on one side.

USES

Insulating building board is a general purpose structural wall board. Its largest use is as an interior finish nailed directly to studs. It is equally adaptable for wall or ceiling work. These boards do not require any further decorative treatment, however, they can be used as a base for plastic paints, wall coverings or other types of finishes.

APPLICATION OF BUILDING BOARD

Insulating board products are generally applied by nailing to the framing members. The framing members are installed on 16 inch centers except in the case of the smaller tileboard which require smaller spacing.

The framing or furring should be installed in the usual manner on 12 or 16 inch centers. Headers should be cut in between framing members at the ends of the insulating boards to provide a nailing base and also in back of chair rails and all other heavy mouldings. Insulating boards should be of sufficient length completely to span between sills and plates or other structural members.

Adjustment to Atmospheric Conditions. The insulating board should be placed singly around the room at least 24 hours prior to erection to allow adjustment to atmospheric conditions.

Nails and Nailing. Where paints and stains are to be used, the insulating board is attached by means of finishing nails or brads, driven at an angle and set. The insulating board should be nailed first to intermediate framing members and then along the edges. On intermediate framing members, nails should be spaced 6 inches apart, driven at a slight angle and the slope alternated from nail to nail. Nails should be spaced 3 inches apart at edges and 3/8 inch away from edges and driven until the heads are flush with the insulating board surface.

Finishing. Calcimine and water paints may be applied directly to unsized insulating board, although calcimine may also be applied to varnish sized surfaces to facilitate removal by washing. Water paints of the casein base class are washable to a certain degree but not quite so much so as oil or varnish paints. A single coat of good casein base water paint will usually give a good coverage on insulating board, although two coats are recommended. Some of these paints are available tinted in a variety of attractive pastel shades. Others can be tinted from the white by the addition of dry colors in accordance with manufacturers' directions.

Size and Application of Paint. Insulating board must be properly sized before application of oil or varnish paints. The size used should be that recommended by the manufacturer. The best results are obtained if the surface is sanded lightly after the size coat has dried thoroughly. The paint may be applied to the surface thus prepared using the desired number of coats for satisfactory results. Some boards are already sized to take oil paints.

(b) SHEATHING

Description.

Insulating board sheathing is a structural sheathing board usually heavier in weight than building board. All of the sheathings on the market today are waterproofed either with an asphalt coating or with an integral asphalt treatment. Some manufacturers also mark the board to show proper nail spacing and alignment. This material is furnished in two main sizes - 4 feet wide and in lengths from 8 to 12 feet. The large boards have square edges. Sheathing is also furnished in 2 x 8 foot sheets with some kind of tongue and groove on long edges. The large boards are 1/2 inch or 25/32 inch thick - the 2 x 8 foot sheets, 25/32 inch thick.

USES

Sheathing is used as a wall sheathing in frame construction with various types of exterior finish such as wood siding, wood shingles, stucco or brick veneer. FHA does not require building paper where insulating board sheathing is used except under stucco or masonry veneer. Many types of farm structures use this material without exterior finish for a complete wall. However, where sheathing is so used, it is recommended that the board be painted.

APPLICATION OF INSULATING BOARD SHEATHING

The 4 foot wide sheathing is applied vertically and nailed at the intermediate studs first, using large headed roofing nails and spacing nails 6 inches apart. Around all edges the nails are spaced 3 inches apart. The 2 x 8 foot sheathing with interlocking horizontal joints is applied horizontally, nailing to intermediate studs first, using the same nail spacing. The sheathing is covered with conventional exterior finish materials such as wood siding (clapboards), shingles, stucco or brick veneer. The methods of application of the exterior finish are practically the same as with lumber sheathing except where rigid shingles are used, in which case furring strips are applied over the insulating board and the shingles nailed to these furring strips. Proper nailing is important. Some manufacturers use patented nails and clips that do not require stripping.

(c) LATH

Insulating lath is an insulating plaster base normally furnished 1/2 inch by 18 inches by 48 inches. All edges are specially grooved to provide additional plaster strength. Some manufacturers furnish patented metal reinforcements for use on long edges to reinforce the plaster at the joints. One half inch of plaster is recommended for use with this product.

USES

Lath may be used as a plaster base for all types of interior wall surfaces. It also provides a degree of sound deadening efficiency on interior partitions.

APPLICATION OF LATH

The studs, joists and rafters should be erected as in ordinary frame construction on 12 or 16 inch centers. For exterior solid masonry walls install 1 x 2 inch furring strips vertically on 12 or 16 inch centers and shim to a true, level plane.

Nails. Blued plasterboard nails with 5/16 inch heads are recommended for insulating board lath - use 1 1/4 inch nails for 1/2 inch lath and 1 3/4 inch nails for 1 inch lath.

Insulating board lath should not be moistened during, prior to or after application. Lath should be applied with long edges at right angles to the framing or furring strips. Center all end joints on framing and stagger the vertical joints or end of each course of lath with the joints of the preceding course. Nail lath securely to framing, using five nails at each stud or nailing member; that is, twenty nails for each lath when framing is on 16 inch centers. Use strips of insulating board lath where piecing out is necessary; do not fill out with wood lath or wood strips. To cover arches, curves and sweeps, first nail at the end, holding it to the required contour and then nail to each successive stud, joist or furring strip.

All outside corners should be reinforced with metal corner beads. Reinforce all reentrant angles with standard expanded metal lath strips 6 inches wide bent into the angle and secured in place by nailing. Use 6 inch strips of expanded metal lath to reinforce all joints between frame and masonry construction. Use 3 inch wide strips of expanded metal lath applied diagonally at corners of door and window openings.

(d) DECORATIVE INSULATING BOARDS

Description.

These interior insulating boards include building board, plank and tileboard, the latter being also known as panels. Building board has previously been discussed: however, it should be kept in mind for use in any decorative treatment.

Insulating plank and tileboard are fairly well standardized in the industry. The plank are manufactured in 8, 10, 12 and 16 inch widths and in 8, 10 and 12 foot lengths. Tileboards are generally produced in 12 x 12 inch, 12 x 24 inch, 16 x 16 inch and 16 x 32 inch sizes. All of these decorative materials come to the job prefinished. Additional painting is not required unless an unusual color scheme is desired. These products are furnished in a variety of colors, including ivory, cream and buff. Some are produced in light shades of green.

USES

The use of interior insulating boards is practically unlimited. As a material for remodeling in the home it can be used in a wide variety of pleasing designs. The products are equally adaptable to new work or remodeling old interiors. They may be applied directly over the old surfaces. Following is a partial list of locations where insulating boards may be used: airport offices, auditoriums, automobile salesrooms, bowling alleys, cocktail lounges, cafes, exhibition buildings, game rooms, libraries, lodge rooms, nurseries, reception rooms, restaurants, summer cottages, theatres and window displays.

Some manufacturers have developed a special clip system and interlocking joints for installing tileboard or panels and other interior finish products, the object being to eliminate exposed nailing. Manufacturers of such systems should be consulted when their products are under consideration.

APPLICATION OF DECORATIVE INSULATING BOARDS

It is especially important that the framing or furring for tileboard units carefully conform to the size of units used. While this allows a choice of 8 or 16 inch spacing with 16 x 16 inch and 16 x 32 inch tile, stripping 8 inches on centers provides for additional nailing which results in superior application. Tileboard (panels) may also be applied by cementing to continuous smooth surfaces.

Furring strips for plank should be at right angles to the plank on 9 inch centers up to a height of 5 feet, and 12 or 16 inch centers above this height, except for 12 or 16 inch widths of plank applied with long edges bearing on framing members on 12 or 16 inch centers.

Nails. Where nailing is to be exposed, cleaned and polished, 1 1/4 inch finishing nails or brads or cadmium plated diamond point nails should be used for 1/2 inch and 1 inch thick insulating boards. Nails shall be driven at an angle, setting below the surface and tapping fiber over surface. Nails may be driven in beaded groove of plank. Where nails are to be covered with panel strips or mouldings, use 1 1/4 inch box, common or galvanized nails for 1/2 inch board, and 2 inch nails of the same type for 3/4 inch or 1 inch board.

Certain manufacturers have introduced concealed nailing for tileboard (panels) and plank. Where such products are to be used, the specifications of the manufacturer should be followed.

Application with Adhesive.

Insulating tileboard (panels) may be applied to sound plaster, smooth wood, plaster-board and other continuous surfaces by means of special adhesives available for this purpose. Tileboard should be applied to solid backing surfaces only with adhesives. For application of tileboard over metal ceilings, rough plaster or other irregular or unsound surfaces, furring strips shall be installed and the tileboard nailed thereto.

The adhesive used should be that specifically recommended by the manufacturer of the product used. Many manufacturers furnish special adhesives for this purpose. In some instances a special adhesive is required for application to painted surfaces.

In applying tileboard with adhesive, apply the adhesive in spots or dabs about 2 inches in diameter, 1/4 to 1/2 inch thick, one in each corner of the square tileboard, and two or more additional spots on the rectangular sizes. Intimate bond is secured by sliding the units into place, using a pressure sidewise against the surface to be finished.

For best results, supplementary nailing is recommended wherever application is made over nailing surfaces. The nailing should proceed in accordance with above paragraph on Nails. Nails shall draw the board so that there is no spring, thus insuring an intimate adhesive bond. Space nails 6 inches apart along all edges at a slight angle, and set flush. Where concealed nailing is used with tileboard, follow manufacturers' specifications.

TYPICAL INSULATING BOARD MATERIALS

Standard Insulating Board Products

PRODUCT	THICK-NESS *	SIZES	FOOTAGE PER BDL (sq. ft.)	PIECES PER BDL	APPROX-WEIGHT PER M Sq. Ft.	MAJOR USE
Building		4 x 7'	168			General purpose
Board	1/2"	4 x 8'	192	6	750	insulating
		4 x 9'	216			board
		4 x 10'	240			
		4 x 12'	288			
		4 x 8'	192		875	Wall sheathing
Sheathing	1/2"	4 x 9'	216		1/2"	for all types
	25/32"	4 x 10'	240	6	1300	of wood framed
		4 x 12'	288		25/32"	construction
	25/32"	2 x 8'	96	6	1300	"
Lath	1/2"	18" x 48"	90	15	760	Plaster base
						for walls,
						ceilings and
						partitions
	1/2"	23"-24" x				Built up roofs,
Roof	1"	47"-48"				masonry floors,
Insulation	1 1/2"		50	7	Varies	
	2"					
		8"	64			
		8' x 10"	80			
		12"	96			
Plank	1/2"	16"	128	12	750	Decorative wall
		8"	80			and ceiling
		10"	100			finish
		10' x 12"	120			
		16"	160			
		8"	96			
		12' x 10"	120			
		12"	144			
		16"	192			
		12" x 12"	32	32		
Tile	1/2	12" x 24"	32	16	750	Decorative wall
		16" x 16"	57	32		and ceiling
		16" x 32"	57	16		finish

* For additional thicknesses consult manufacturer.

The ASHVE Guide 1947 gives the conductivity (k) of these materials as .33 B.T.U.

5. SLAB INSULATIONS

Description.

Slab insulations are small, rigid units normally furnished in 1 inch thickness or greater. They may be fabricated from thinner boards to the desired thickness, or they may be made of one piece.

(a) *Corkboard* is made from the bark of the cork tree which grows along the western Mediterranean. The cork is ground into 1/4 inch to 5/8 inch granules and compressed under heat. Corkboard is made in slabs ranging in size from 12 x 36 inches to 36 x 36 inches and in thicknesses from 1 inch to six inches. The principal use of corkboard is for cold storage insulation.

(b) *Wood Fiber and Cement Slab Insulations*. These slabs are made from wood fibers and Portland cement or special type cements. They are produced in various sizes and thicknesses. These products are used for insulating roofs, floor and ceiling installations and non-bearing partitions.

(c) *Mineral Wool Slabs*. Products of this type are made from both mineral wool and glass wool. These products are also used for industrial and cold storage work, and are made by various manufacturers of mineral wool.

(d) *Insulating Board Slabs*. These materials are made by laminating several pieces of insulation board together. These slabs are also used primarily for cold storage work.

(e) *Cellular Glass Slabs*. Slabs made of glass in cellular form and cut to size. Each cell is closed and impervious to air or water. These products are generally used for cold storage work and roof insulation.

6. REFLECTIVE INSULATIONS

Description.

Reflective insulations are composed of metallic surfaces with or without some type of backing. They are different from other types of insulation in that they depend entirely on their surface characteristics for their insulation value. It should be kept in mind that reflective type insulations should always be installed so that the reflective surface faces an air space of at least 3/4 inch. Bright metallic surfaces such as aluminum foil have a higher reflectivity then ordinary surfaces such as wood, plaster, etc. If an air space is faced with a reflective surface the insulating effect is increased because such a surface is capable of repelling a large part of the heat that would normally cross the stud space by radiation. Reflective type materials, if installed properly, have an advantage in that they act as efficient vapor barriers, provided they are installed in a continuous fashion without openings or joints through which vapor may pass. At the present time there are four different types of reflective insulating materials on the market. They are: (1) aluminum foil, (2) gypsum board with an aluminum surface, (3) dull-sheet steel, and (4) paper faced with aluminum foil, one or both sides, or faced with aluminum powder. The powder type facing has a less effective value than the bright foil. Reflective insulations may also be used with other types of insulation, such as blankets and insulating board. Some manufacturers of reflective sheets furnish a material composed of several layers of foil which divide an air space into several smaller spaces.

USES

Reflective type insulations may be used as roof insulation, between the rafters; as attic floor insulation, over joists or beams; in exterior wood or masonry walls. This material has also been used in cold storage work.

APPLICATION OF REFLECTIVE INSULATIONS

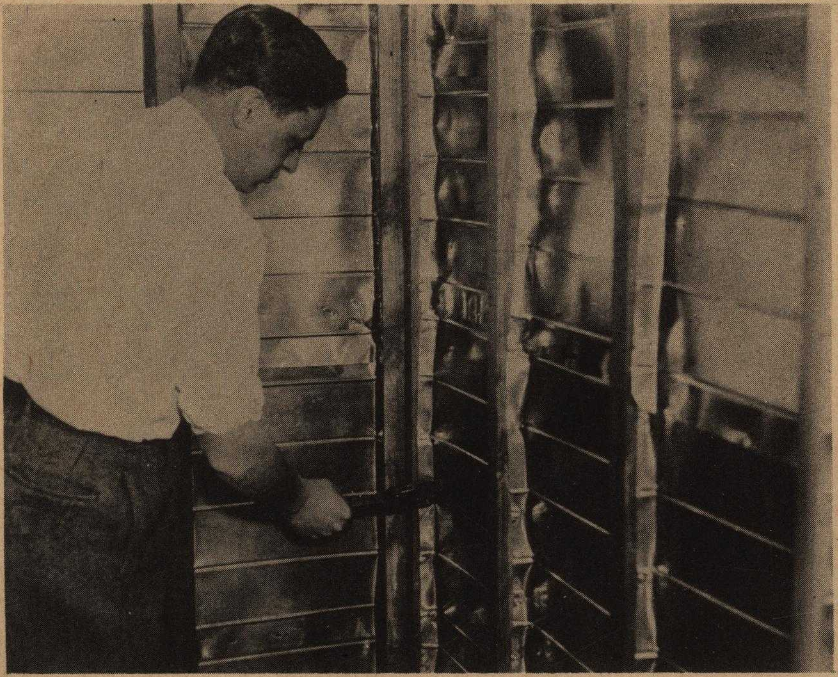
These materials are normally furnished in sheets adaptable to standard framing. The material is formed to fit the space and is nailed or stapled approximately every six inches.

7. MISCELLANEOUS INSULATIONS

Other types of insulation which do not fall into any of the above classes are:

Sprayo-Flake. This is a special process of insulating which consists of spraying through a specially constructed air gun dry fibrous materials at the same time with an atomized adhesvie. The adhesive primes the surface being treated and coats the fibers as they leave the nozzle. A build-up of material can be secured to any desired thickness.

Insulated Brick Siding. Insulating board coated with asphalt and granules with simulated brick surface, or a plain granule coated surface.



APPLICATION OF REFLECTIVE TYPE INSULATION - Courtesy of American Flange and Manufacturing Company.

SECTION V

VENTILATION AND VAPOR BARRIERS

Excessive dampness in buildings or wetness of parts of them can result either from leakage of rain inward from the outside or from condensation of water vapor generated on the inside. The underlying cause of condensation is simple, but the great differences in house design and construction, in climate and in the living habits of families make it impractical to formulate simple remedies applicable to all cases. Obviously, however, builders and home owners should be acquainted with the general principles involved.

Condensation can occur under either summer or winter conditions, but the causes and results are different for the two seasons. In winter, water vapor is liberated in houses or buildings by cooking, washing and bathing, sometimes by evaporation from basement floors or earth in crawl spaces, by the use of unvented fuel burning devices, from potted plants, from clothing dried in the house and, in some cases, by humidifiers used for the purpose. Water vapor is capable of permeating most ordinary building materials such as wall paper, plaster and wood. Hence, high humidity in a house may result in condensation of water not only on the windows but also on or within the exterior walls, the ceiling or the roof. In winter, condensation on window panes is often an indicator of excessive humidity and additional ventilation of the house is a usual remedy.

Summer condensation may be preventable by ventilation in conjunction with heat either from sunlight or from some heating device such as a water heater. This is not always adequate so that driers, employing calcium chloride, silica gel or other agents, are often used.

Often a closed, unheated house in a temperate climate becomes damp on the inside. Weather changes contribute to this result. When the basement floor or earth under the house is warmer than the house, convection currents occur. Also, water evaporates from the basement floor and, carried upward by the convection currents, condenses on surfaces or in materials in the upper part of the house. By this means, water is transferred from a basement or a crawl space to the upper part of a house. When the basement is cooler than other parts of the house, the convection currents cease; the air in the house stratifies with the cool air at the bottom and the warm air above.

Insulation

Water vapor generated within a house in winter spreads in all directions by diffusion assisted by air motion. It passes through ordinary wall paper and plaster and will condense within a wall or other building element wherever a surface is below the dew point. If condensation occurs in a wall, it is likely to be at or near the outside surface since that portion is coldest and an insulated wall is expected to be colder on the outside, and warmer on the inside, than an uninsulated wall. Also, unprotected insulation, although effective as a barrier to heat, is not usually a barrier to water vapor migrating through the wall. For these reasons more precautions against condensation are essential when insulation is used. These precautions take the form of ventilation, minimizing water vapor generation, use of vapor barriers, particularly in new houses, wall ventilation, etc. The effect of insulation in ceilings or roofs is similar. An attic is colder in winter after insulation is installed in its floor and roof boards are colder after insulation is placed under them.

Ventilation

Various means have been suggested to prevent excessive humidity in occupied houses in winter, including the use of absorbent materials such as calcium chloride, silica gel, etc., but ventilation probably is most economical and convenient during that season. Condensation can be prevented in any house or building by heat and sufficient ventilation. Ventilation is effective, as previously pointed out, because warm air can carry much more water vapor, pound for pound, than cold air. Consequently, warm air, leaving a house, conveys more water vapor than is brought in by the cold air which replaces it. Air exits in the form of exhaust grills, ducts, chimneys, etc., or even open windows should be near the sources of water vapor so that the vapor can be expelled without undue loss of heat. An open or partially open window in a kitchen or laundry is more effective than one in a living room or bedroom.

Rules to Remember

1. Use a good vapor barrier material on the inside (room-side) of all insulated walls, floors, ceilings or roofs whenever construction conditions permit. This barrier may be part of the insulation or a vaporproof sheathing paper such as an asphalt impregnated and coated paper, applied to the framing members before the lath and plaster are applied.

2. Use materials on the cold side of the insulation that vapor will pass through readily. If this is impossible as in the case of metal roofs and walls or built-up roofing, provide direct ventilation from the cold side of the insulation to the outdoor air. *Do not* use vaporproof sheathing papers, particularly laminated asphalt papers or metal foil on the cold side of the insulating materials.

3. Ventilate attics and roof spaces above the insulation direct to the outdoor air, summer and winter alike. Provide adequate ventilation as discussed previously in this chapter.

4. Use humidifiers andother moisture providing devices intelligently, especially in cold weather. Indoor humidities should be kept within the limits shown in the following table:

Outside Temperature	Inside Relative Humidity
Below 0	Not more than 20%
0 to 20° above	Not more than 30%
20° above and over	Not more than 40%

If no method of measuring humidity or automatically controlling humidities within these limits is available the formation of moisture on single glass windows may be taken as evidence of excessive humidity.

5. Insulate existing houses without fear of condensation even though no vapor barrier can be installed with the insulation. In buildings where the occupants are likely to generate too much humidity or there is evidence of dampness, a good vapor barrier may be provided by painting inside surfaces with two coats of lead and oil or aluminum paint.

SECTION VI

FARM INSULATION

Farm buildings today as contrasted with other farm equipment are still largely in the "horse and buggy" stage. In an era when high production and low waste are requisites for success a large proportion of our farm shelters are woefully inadequate.

Good service buildings are essential to an efficient farming enterprise. Well arranged shelters and convenient location of feeding and watering facilities will make the best use of the operator's time. Warm construction will make possible the most efficient utilization of feed. Good ventilation will protect the animals from disease and the buildings from rapid depreciation. And over and above these desirable features is the effect on the man who does the work. A good worker enjoys using good facilities, and when his "morale" is thus upheld he does a better job.

Consider for instance buildings designed to house livestock. In the old days, they were built to provide protection from severe weather until such time as the animals could again live outdoors and produce their eggs, milk and pork under natural conditions. A hen was expected to produce 100 or less eggs a year. The average cow's milk production was from 2,500 to 3,000 pounds a year. Sows produced one litter of pigs, of which 40 to 50 percent died before reaching a marketable age. Under such conditions buildings did not require special consideration to the problem of maintaining production during cold weather. Maintaining life was the principal concern.

It's a different story today. The poultryman wants 200 eggs per year from each hen. Dairy herds frequently are composed of cows that average from 7,500 to 10,000 pounds of milk a year. Now sows produce two litters a year, and good operators expect to keep mortality to 10 to 15 percent. This is the kind of production that demands facilities that will enable the farmer to control the animals' environment.

What part does insulation play in helping to obtain these greater results? First of all, the modern farm building should protect animals from extremes of heat and cold, from sudden temperature changes and from drafts. The interiors should be reasonably dry and free from disagreeable or unhealthy odors. The interior surfaces should not sweat or frost. In order to control the atmospheric conditions of an unheated farm structure used for animal housing or storage, the combined use of insulation, ventilation and vapor barriers is required.

As discussed previously, heat will pass through all building materials to some extent when it is warmer or colder outside than inside the building. No material will stop entirely the passage of heat. However, farm insulation as in other buildings is used to slow down the passage of heat through walls and roofs so as to keep the building warmer in winter and cooler in summer.

Ventilation is also very important in any discussion of insulating farm buildings. Farm ventilation is necessary first for regulating inside temperatures and second, for removing excessive quantities of moisture and odors given off by livestock and poultry. Ventilating can be done through open windows and by means of flues or through the use of thermostatically controlled fans. By carrying off excess moisture, ventilation reduces the amount of vapor in the air and thus helps prevent sweating or frosting. Good ventilation is possible only in structures which are kept tight and reasonably warm. Consequently, insulated buildings are easier to ventilate than poorly constructed uninsulated buildings.

Vapor Barriers in Farm Structures.

The reasons for using vapor barriers in farm structures are the same as those for other buildings, as explained previously. However, there is one important difference; in relation to the volume of enclosure the amount of moisture present in animal and storage rooms or buildings is usually much greater than in the case of structures used only for human occupancy. The use of vapor barriers in farm structures is therefore correspondingly greater.

The important interrelationship between insulation, ventilation and vapor barriers is thus apparent. Insulation keeps buildings warmer in winter and cooler in summer. Ventilation removes moisture and stale air and brings in fresh air and helps to regulate temperatures. Insulation and ventilation together prevent surface condensation and make it possible to have buildings that are both warm and dry. Vapor barriers retard the entrance of vapor into walls and thus prevent condensation within them.

ECONOMIC REASONS FOR THE INSULATION OF FARM BUILDINGS

There are several economic reasons for using insulation. Some of the reasons for insulation are (1) increase on production, (2) lessens mortality, (3) lessens food spoilage, (4) increases life of building and (5) saves fuel. In addition to the primary economic advantages involved, insulation of farm buildings also provides greater comfort for the animals as well as for the caretakers.

Increase in Production

The heat needed for dwellings is obtained artificially by the combustion of wood, coal, oil or gas. The amount of fuel burned is varied to meet the demand. Thus it is possible to maintain a fairly uniform temperature within the building. The heat of warming animal shelters must come either from the bodies of the animals or from burning fuel. Nearly always the heat is provided by the animals,- hence it is limited to the heat production of their bodies. The inside temperature thus fluctuates to a considerable extent with variations in the outside temperature.

Animals or poultry will consume approximately the same amount of feed regardless of the temperature of their shelters. However, if a building is extremely cold, more of the food will be used for keeping up body temperatures and less for production. This will mean for example a reduction in the output of milk or eggs. Therefore warm inside winter temperatures result in greater production.

In a bulletin published by the United States Department of Agriculture, attention is called to the fact that experience has shown it pays to keep cows comfortable. Experiments made at the Institute of Animal Nutrition at Pennsylvania shows that under the usual conditions of intensive cattle feeding the cost of maintenance increases 1.4 percent for each degree the temperature falls below the point at which the animal begins to feel cold.

Maximum production depends upon preventing sudden changes in temperatures. Rapid temperature variations are more dangerous than steady cold. Even in mild climates for example, sudden temperature fluctuations in poultry houses often cause the output of eggs to fall off. The inside temperature of an insulated building is not subject to quick changes because the insulation holds the heat inside and the building cools off gradually.

Lessens Mortality

According to farm experts the health of young animals such as chicks, calves and pigs is easily undermined by cold and drafty buildings. Insulation helps provide the needed warmth. Insulation also reduces drafts in two ways - first, by providing tighter construction, thus reducing air leakage, and second, by increasing surface temperatures.

Cold walls and ceilings create drafts because air cooled by these surfaces drops to the floor, thus starting a circulation of the air. According to many farm authorities, by reducing to a minimum these serious causes of illness, insulation enables the farmer to keep his stock healthier and to raise more animals to a marketable or productive age.

Lessens Food Spoilage

Temperature and humidity variations have a direct effect on the quality of fruits and vegetables held in storage. Freezing ruins many crops. High humidities are desirable in others in order to prevent shrinkage. Wide variations in temperature generally are harmful. Insulation protects the harvested crops from freezing during cold weather and from excessive heat in summer. Insulation also helps control the humidity and the operation of the ventilating system, both of which are essential in properly maintaining a good storage building.

Increase Life of Building

Insulation by making possible good ventilation and helping to prevent condensation keeps buildings dry. Damp farm buildings deteriorate rapidly Repeated wetting and drying warps, shrinks and rots framing members and siding. This permits drafts in the buildings which then become colder and less efficient. Therefore an insulated building will last longer.

Saves Fuel

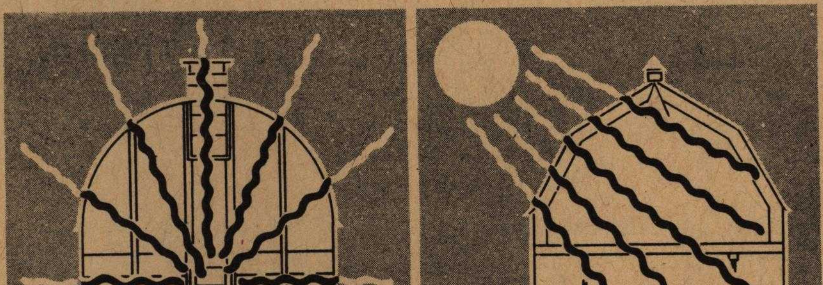
Where fuel is used to maintain inside temperatures in farm structures, insulation reduces the amount consumed. If a building is heated by the use of wood or coal, insulation not only reduces the cost of the fuel but also reduces the amount of wood or coal that must be carried in for heating purposes. If oil, gas or electricity is used for heating purposes, insulation reduces the size of the fuel bills appreciably.

For buildings such as a farm home the saving often is a sizeable amount. Whether the saving is large or small it is over and above the other advantages obtained by insulating a building.

Greater Comfort

The foregoing paragraphs give the most important economic reasons for insulating farm buildings but the matter of comfort for both the livestock and man who takes care of it is also important even though it cannot be evaluated exactly in dollars and cents. However, this increased comfort is a bonus. As a prominent farm authority has stated, "Feeding, milking and other routine operations are more efficiently accomplished in the barn of comfortable temperature than under conditions that arouse an instinctive desire on the part of the workman to slight the work in order to get it done quickly."

* * *



WHY INSULATION IS NEEDED

WHEN IT'S COLD OUTDOORS, indoor heat flows out through walls and roof (as well as through windows and doors) because ordinary building materials are good conductors of heat. Insulation slows up this loss of heat, helps keep it inside.

WHEN IT'S HOT OUTDOORS, heat flows into an uninsulated building. In this case, insulation applied to the roof and walls slows up the penetration of heat, keeping the interior of the insulated building much more comfortable in summer.

CONCLUSIONS

1. It is possible to save heat by the use of insulation. Application of insulation to exposed walls, ceilings or roofs can reduce fuel costs by as much as 40%.

2. Insulation helps keep the building cooler in hot weather because it reduces the flow of heat into the house during the warmer part of the day.

3. Insulation and double windows or storm windows reduce winter heat loss by more than one-half.

4. Weatherstripping saves heat by reducing the air leakage around windows and doors.

5. The proper application of insulating materials is of major importance. If insulation is not applied properly the value may be greatly reduced or completely lost. A good insulation job depends as much on good workmanship as on the proper materials.

6. All manufactured insulations are efficient. Different types and thicknesses have been developed for different climates and for different types of buildings.

7. Partial insulation; that is, insulation of some parts of the building and not others is worthwhile. For instance, the heat loss through the ceiling or roof of some buildings is one third or more of the total. Insulating this area would save a large part of that heat loss. In other buildings the wall losses are greatest and roof insulation could effect only a small part of the possible saving.

8. There is no general answer to the question "How much insulation is enough"? There are, however, five important factors that should be considered in the selection and use of insulation. They are: (1) climate, including the necessity of protection from outside heat, (2) local fuel costs and the efficiency of the heating plant, (3) surface area in the building that can be insulated, (4) the natural heat insulating value of the construction itself, and (5) the comfort of the occupants both winter and summer.

9. The use of vapor barriers in new construction is recommended on the warm side of insulated walls, ceilings and roofs where the average January temperature is 35° or colder.

QUESTIONS

True False

Section I

1. Primitive kinds of insulation were more efficient and durable than those of modern manufacture.

2. Buyers of houses never want to know whether a house is insulated or not.

Section II

3. Conduction, convection and radiation are terms describing the transfer of heat.

4. The passage of heat through a solid body is called conduction.

5. The thousands of tiny air pockets in bulk insulation do not slow down the transfer of heat.

6. The "k" factor and the "C" factor of an insulating material are the same thing.

Section III

7. Insulation is intended to keep heat where it belongs -- inside in winter and outside in summer.

8. Insulation may be installed in floors, walls, ceilings and roofs.

9. In a typical two story house the heat loss is greatest thru the ceiling.

10. If insulation is installed in a home when built, a smaller heating plant will be big enough to heat the structure.

11. What percentage of fuel saving may be reasonably expected when a house is fully insulated and has storm windows and doors? 50%?

12. A purchaser should never be told how to install the insulation he is buying.

Section IV

13. The best way to install insulation in the walls of an already-built house is by means of a blowing machine,

14. Batt and Blanket insulations, as sold, are both less than 48" long.

15. Insulating Board may be used as an interior finish of a room.

Section V

16. Drying clothes in the house does hot create indoor humidity.

17. A vapor barrier should be installed on the inside face of the wall studing.

18. Vermiculite is furnished in blanket type materials.

Section VI

19. Ventilation is necessary in farm buildings in order to remove excessive moisture.

20. Insulation increases the life of a farm building.

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